

SYNCHRONOUS DATA TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

This application claims benefit of Japanese Patent Application No. 2000-236718 filed on August 4, 2000, the contents of which are incorporated by the reference.

The present invention relates to synchronous data transmission systems for transmitting synchronous data via a synchronous line.

There are cases where it is desired to transmit synchronous signal varying with time, such as voice and motion picture signals among a plurality of terminals via a synchronous transmission lines. Prior art techniques concerning such synchronous data transmission are disclosed in Japanese Patent Laid-Open No. 62-125728 as "Clock Permeable Synchronous Data Transmission System", in Japanese Patent Laid-Open No. 63-187942 as "Data Transmission System" and so forth.

In such cases, the data transmission is subject to quality deterioration due to different data sampling clocks of the individual terminals. For example, when the transmission side data generation sampling clock is at a higher rate than the reception side data reproduction sampling clock, overflow of data is generated on the reception side, resulting in missing of reproduced data. On the other hand, when the reception side sampling clock is at a higher rate, underflow of data is generated, resulting in stoppage of the reproduction or missing data therein.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a synchronous data transmission system capable of reducing quality deterioration of data transmission due to an overflow or underflow generated by the difference between the transmission side data generation sampling clock and the reception side data reproducing sampling clock.

According to an aspect of the present invention, there is provided a synchronous data transmission system for transmitting such data as voice or image data between a first and a second terminals via an asynchronous transmission line, wherein: the first and second terminals each comprise a data generator and a data reproducer operable under control of a clock from a sampling clock generator, and a transmission buffer and a plurality of reception buffer stages connected to the data generator and the data reproducer, respectively.

According to another aspect of the present invention, there is provided a synchronous data transmission system for transmitting such data as voice or image data between a first and a second terminals via an asynchronous transmission line, wherein: the first and second terminals each comprise a data generator and a data reproducer operable under control of a clock from a sampling clock generator, and a transmission buffer and a plurality of reception buffer stages connected to the data generator and the data reproducer, respectively,

and the first and second terminals each further comprise an asynchronous transmission line interface connected to the asynchronous transmission line.

The synchronous data transmission system further comprises a clock synchronizing means for synchronizing clocks generated in the sampling clock generators in the first and second terminals. The synchronous data transmission system further comprises a frequency difference eliminating means for eliminating the frequency difference between the clocks generated in the sampling clock generators in the first and second terminals. A synchronous data transmission line is connected to the data generators and the data reproducers in the first and second terminals. The sampling clock generators in the first and second terminals are controlled on the basis of the received data from the asynchronous transmission line interface.

According to other aspect of the present invention, there is provided a synchronous data transmission system comprising a first and a second terminals and a synchronous transmission line connected between first and a second terminals for voice or image communication with each other, each terminal including a voice or image input means, a sampling clock generator, an A/D converter for digitalizing the output of the voice input means, a data generator, operable with the output of the sampling clock generator, for generating data on the basis of the output of the A/D converter, a transmission buffer

receiving the generated data, a plurality of reception
buffer stages supplied with the received data via a
asynchronous transmission line, a data reproducer
operable with the output of the sampling clock generator,
5 for reproducing data from the plurality of reception
buffer stages, a D/A converter for converting the
reproduced data to an analog signal, a voice or image
output means for outputting voice based on the D/A
converter output, the data stored in the transmission
10 buffer having been packeted in certain time units (t)
and being outputted via asynchronous transmission line
interface to the asynchronous transmission line for the
time unit (t), the data received from the asynchronous
transmission line being stored via the asynchronous
15 transmission line interface in the reception buffer, the
data stored in the reception buffer being transmitted
to the data reproducer, the reception buffer being
capable of storing data received from the asynchronous
transmission line for a plurality of times ($n \times t$) in every
20 unit time (t), and the data reproducer reproducing data
when data for the plurality of times ($n \times t$) has been
stored.

The synchronous data transmission system further
comprising a sampling clock synchronizing means for
25 synchronizing the sampling clocks of the sampling clock
generators in the first and second terminals by inputting
the output of the sampling clock generator in one terminal
to the sampling clock generator in another terminal. The

frequency difference between the sampling clocks generated in the sampling clock generators in the first and second terminals is eliminated by inputting the clock from the sampling clock generator in one terminal to the sampling clock generator in another terminal. The sampling clock frequency of one terminal is made closer to the sampling clock frequency of another terminal by estimating the sampling clock on the basis of the data received from the asynchronous transmission line.

Other objects and features will be clarified from the following description with reference to attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the construction of a first embodiment of the synchronous data transmission system according to the present invention;

Fig. 2 shows an embodiment, in which motion picture is transferred between the first and second terminals by using the asynchronous transmission line;

Fig. 3 shows an embodiment, in which synchronous non-restricted digital communication line data of ISDN (integrated service digital network) or the like is transferred by using the asynchronous transmission line;

Fig. 4 is a block diagram showing the construction of a third embodiment of the synchronous data transmission system according to the present invention; and

Fig. 5 is a block diagram showing the construction

of a fifth embodiment of the synchronous data transmission system according to the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention
5 will now be described with reference to the drawings.

According to the present invention, in the transmission of a synchronous signal, such as a voice or a motion picture signal, between different terminals (i.e., a first and a second terminal) via an asynchronous
10 transmission line, deterioration of the data quality is presented, which might otherwise be generated due to the difference of a transmission side data generation sampling clock and a reception side data reproduction sampling clock from each other. Fig. 1 is a block diagram
15 showing the construction of a first embodiment of the synchronous data transmission system according to the present invention. This embodiment concerns the transmission of voice as signal transmitted and received between such terminals.

20 The synchronous data transmission system shown in Fig. 1 comprises a first and a second terminal 100 and 200 and a synchronous transmission line 300. Microphones 101 and 201 and loudspeakers 102 and 202 are connected to the first and second terminals 100 and 200,
25 respectively. The first and second terminals 100, and 200 include sampling clock generators 103 and 203, data generators 104 and 204, data reproducers 105 and 205, transmission buffers 106 and 206, reception buffers 107

and 207, asynchronous transmission line interfaces 108 and 208, analog-to-digital (A/D) converters 109 and 209 and digital-to-analog (D/A) converters 110 and 210, respectively. The outputs of the sampling clock
5 generators 103 and 203 are supplied to the data generators 104 and 204 and the data reproducers 105 and 205.

The first and second terminals 100 and 200 have voice input/output functions constituted by microphones 101 and 201 and loudspeakers 102 and 202. The first and
10 second terminals 100 and 200 perform voice communication with each other via the asynchronous transmission line 300. At this time, the sampling clock generators 103 and 203 generate sampling clocks of voice data in the first and second terminals 100 and 200. Voices inputted from
15 the microphones 101 and 201 are supplied to the A/D converters 109 and 209, which in turn outputs digitalized data (i.e., digital data) to the data generators 104 and 204.

The voice input signals are digitalized by using
20 sampling clocks generated in the sampling clock generators 106 and 206. The data stored in the transmission buffers 106 and 206 have been packeted in certain time units (t). The data stored in the transmission buffers 108 and 208 are outputted via the
25 asynchronous transmission line interfaces 108 and 208 to the asynchronous transmission line 300. This data transmission using the asynchronous line 300 is performed for the time unit (t).

The data received from the asynchronous transmission line 300 are stored via the asynchronous transmission line interfaces 108 and 208 in the reception buffers 107 and 207. The data stored in the reception buffers 107 and 207 are transmitted to the data reproducers 105 and 205. The D/A converters 110 and 210 converts the outputs of the data reproducers 105 and 205 to analog data by using the sampling clocks generated in the sampling clock generators 103 and 203, and output the analog converted data to the loudspeakers 102 and 202. The reception buffers 107 and 207 can store data received from the asynchronous transmission line 300 for a plurality of times ($n \times t$) in every unit time (t). The data reproducers 105 and 205 reproduce data when data for the plurality of times ($n \times t$) has been stored.

The operation of the synchronous data transmission system shown in Fig. 1 will now be described. A case will be considered, in which the first terminal 100 transmits voice data via the asynchronous transmission line 300 to the second terminal 200. The A/D converter 109 converts the data inputted as analog data from the microphone 101 to digital data. The conversion of the analog to the digital data is performed by using the sampling clock generated in the sampling clock generator 103 in the first terminal 100. At this time, the frequency of the sampling clock is chosen to be f_1 (Hz), and the accuracy of conversion is chosen to be m bits.

The generator 104 executes data processing on the

data sampled in the A/D converter 109 to generate packets each for each unit of processing in the asynchronous transmission line 300. This data processing is performed in units of times t (s). The data quantity w is expressed with $t/f_1 \cdot m$ bits. The data w is stored in the transmission buffer 106, and is outputted via the asynchronous transmission interface 108 to the asynchronous transmission line 300 for each time t .

The data outputted to the asynchronous transmission line 300 is stored via the asynchronous transmission line interface 208 of the second terminal 200 in the reception buffer 207 therein. The reception buffer 207 has n buffer stages, and upon w data receipt ($n - 1$) times from the asynchronous transmission line 300, it transmits data in units of m bits to the data reproducer 205. The data reproducer 205 reproduces data by using the sampling clock generated in the sampling clock generator 203 in the second terminal 200. The frequency of the sampling clock at this time is chosen to be f_2 (Hz).

As for the data quantity w that is transferred via the asynchronous transmission line 300, the time t_1 of data generation in the first terminal 100 is expressed as $w \cdot f_1 / m$, and the time t_2 of data generation in the second terminal 200 is expressed as $w \cdot f_2 / m$. Where the sampling frequencies in the first and second terminals 100 and 200 are the same (i.e., $f_1 = f_2$), $t_1 = t_2$. The voice inputted from the microphone 101 of the first terminal

100 is outputted without interruption from the
loudspeaker 202 of the second terminal 200.

Actually, the sampling frequencies in the first and
second terminals are not perfectly the same. Where f_1
5 > f_2 , overflow of the received data occurs. Where f_1
< f_2 , underflow of the received data occurs. In either
case, missing of voice occurs. Where the reception
buffer 207 shown in Fig. 1 is an n-stage buffer, it is
possible to obtain a structure, which is less subject
10 to underflow and overflow. Denoting $\Delta f = f_1 - f_2$, when
 Δf is positive, overflow occurs with $t / \Delta f$ (s) in the
reception buffer 207 as one-stage buffer.

Where the reception buffer 207 is an n-stage buffer,
overflow occurs therein with $n \cdot t / \Delta f$ (s). When Δf is
15 negative, underflow occurs with $t / \Delta f$ (s) in the reception
buffer 207 as one-stage buffer. On the other hand,
underflow occurs with $n \cdot t / \Delta f$ (s) in the reception buffer
207 as n-stage buffer. It will be seen that it is
possible to extend the time until the overflow or
20 underflow by n times and thus improve the quality of the
synchronous data such as voice data.

Other embodiments of the synchronous data
transmission system according to the present invention
will now be described with reference to Figs. 2 to 5.
25 Fig. 2 shows an embodiment, in which motion picture is
transferred between the first and second terminals by
using the asynchronous transmission line. Fig. 3 shows
an embodiment, in which synchronous non-restricted

digital communication line data of ISDN (integrated service digital network) or the like is transferred by using the asynchronous transmission line. The operations of these embodiments are substantially the same as in the case of Fig. 1. In these embodiments, constituent elements corresponding to those in the above first embodiment are designated by like reference numerals.

The second embodiment of the synchronous data transmission system according to the present invention shown in Fig. 2 comprises a first and a second terminal 100a and 200a and an asynchronous transmission line 300a. Image input units (i.e., cameras) 111 and 211 and image output units (i.e., displays) 112 and 212 are connected to the first and second terminals 100a and 200a, respectively. The first and second terminals 100a and 200a and the asynchronous transmission line 300a are the same as the corresponding elements in the first embodiment. In this embodiment, however, the A/D converters 109 and 209 and the D/A converters 110 and 210 shown in Fig. 1 are not provided.

The third embodiment of the synchronous data transmission system shown in Fig. 3 according to the present invention comprises a first and a second terminal 100b and 200b and an asynchronous transmission line 300b. Synchronous non-restricted digital transmission lines 400 and 500 are connected to the first and second terminals 100b and 200b. The first and second terminals

100b and 200b and the asynchronous transmission line 300b
are the same and operate in the same way as the first
and second terminals 100a and 200a and the asynchronous
transmission line 300a, respectively, in the second
embodiment.

Fig. 4 is a block diagram showing the construction
of a third embodiment of the synchronous data
transmission system according to the present invention.
This synchronous data transmission system comprises a
first and a second terminal 100c and 200c and an
asynchronous transmission line 300c. Like the case of
the first and second terminals 100 and 200 shown in Fig.
1, microphones 101 and 202 and loudspeakers 102 and 202
are connected to the first and second terminals 100c and
200c. This third embodiment is different from the first
embodiment shown in Fig. 1 in that it has a sampling clock
synchronizing means (such as a well-known PLL,
phase-locked loop circuit or the like) for synchronizing
the sampling clocks of the sampling clock generators 103
and 203 in the first and second terminals 100c and 200c
by inputting the output of the sampling clock generator
103 to the sampling clock generator 203.

Such sampling clock synchronizing means is
applicable to the second and third embodiments shown in
Figs. 2 and 3 as well. In the case of the fourth
embodiment shown in Fig. 4, the frequency difference
between the sampling clocks generated in the sampling
clock generators 103 and 203 in the first and second

terminals 100c and 200c is eliminated by inputting the clock from the sampling clock generator 103 in the second terminal 100c to the sampling clock generator 203 in the second terminal 200c. With this function, it is possible to further reduce Δf as described before in connection with the first embodiment shown in Fig. 1 and further alleviate the deterioration of the data quality compared to the first embodiment.

Fig. 5 is a block diagram showing the construction of a fifth embodiment of the synchronous data transmission system according to the present invention. This embodiment comprises a first and a second terminal 100d and 200d and asynchronous transmission line 300d. Microphones 101 and 201 and loudspeakers 102 and 202 are connected to the first and second terminals 100d and 200d. In this fifth embodiment, the first terminal 100d and the asynchronous transmission line 300d are the same as the corresponding elements in the first embodiment. In the second terminal 200d, however, the data deterioration is further reduced in such a manner as to make the sampling clock frequency of the second terminal 200d closer to the sampling clock frequency of the first terminal 100d by estimating the sampling clock of the first terminal 100d on the basis of the data received from the asynchronous transmission line 100d.

As described before in connection to Fig. 1, the data outputted from the first terminal 100d to the asynchronous transmission line 300d is transmitted in

units of times t (s). The unit time t is measured in the terminal 100d, and different from time t_2 measured in the second terminal 200d. This time difference is estimated in the asynchronous transmission line

5 interface 208 and the sampling clock generator 203. Then, $\Delta f = f_1 - f_2$ is reduced by having f_2 approximate f_1 , i.e., the frequency of the sampling clock generated in the sampling clock generator 103 in the terminal 100d. The data quality deterioration is further reduced with this
10 function along with the construction of the first embodiment shown in Fig. 1. Particularly, the fifth embodiment has an effect that the data quality deterioration is reduced even with reduction of the number n of stages of the reception buffers 107 and 207
15 shown in Fig. 1.

As has been described in the foregoing, with the synchronous data transmission system according to the present invention it is possible to obtain the following pronounced practical advantages. By transmitting
20 synchronous data via the asynchronous transmission line, it is possible to alleviate the deterioration of the synchronous data due to overflow and underflow of data generated by a clock slip. The construction of preventing the synchronous data quality deterioration
25 due to the clock slip is very simple. In the transfer of data an asynchronous communication line, i.e., a communication line other than the synchronous communication line, the transfer of synchronous data is

possible while alleviating the data quality
deterioration.

Changes in construction will occur to those skilled
in the art and various apparently different modifications
5 and embodiments may be made without departing from the
scope of the present invention. The matter set forth in
the foregoing description and accompanying drawings is
offered by way of illustration only. It is therefore
intended that the foregoing description be regarded as
10 illustrative rather than limiting.